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DEMOGRAPHIC TRANSITIONS AND ECONOMIC MIRACLES IN EMERGING ASIA

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Abstract

DEMOGRAPHIC TRANSITIONS AND ECONOMIC MIRACLES IN EMERGING ASIA

The demographic transition — a change from high to low rates of mortality and fertility — has been more dramatic in East Asia during the 20th century than in any other region or historical period. By introducing demographic variables into an empirical model of economic growth, this essay shows that this transition has contributed substantially to East Asia's so-called economic miracle. The "miracle" occurred in part because East Asia's demographic transition resulted in its working-age population growing at a much faster rate than its dependent population during the period 1965-1990, thereby expanding the per capita productive capacity of East Asian economies. This effect was not inevitable; rather, it occurred because East Asian countries had social, economic, and political institutions and policies that allowed them to realize the growth potential created by the transition. The empirical analyses indicate that population growth has a purely transitional effect on economic growth; this effect operates only when the dependent and working-age populations are growing at different rates. An important implication of these results is that future demographic change will tend to depress growth rates in East Asia, while it will promote more rapid economic growth in Southeast and South Asia.

JEL J1, O1, O4, and O53

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The Agenda

This paper has two objectives. The first is to estimate an empirical model that isolates the impact of demographic variables on economic growth. It does so within a framework of economic and demographic transition. The second objective is to use these results to infer how much of the East Asian[1] miracle can be explained by the region's spectacular demographic transition.

The paper begins, therefore, by revisiting the debate on the impact of population growth on economic growth. "Population pessimists" believe that rapid population growth is immiserizing, because it tends to overwhelm any induced response by technological progress and capital accumulation (Coale and Hoover 1958; Ehrlich 1968). "Population optimists" believe that rapid population growth allows countries to capture economies of scale and promotes technological and institutional innovation (Boserup 1981; Kuznets 1967; Simon 1981). Research culminating in the 1980s cast doubt upon both views: investigators showed that population growth has neither a significant positive nor a significant negative impact on economic growth (Bloom and Freeman 1986; Kelley 1988). These studies were typically based on cross-country regressions of income per capita growth on population growth, controlling for a variety of other influences. As Kelley and Schmidt put it recently:

> Possibly the most influential statistical finding that has shaped the "population debates" in recent decades is the failure, in more than a dozen studies using cross-country data, to unearth a statistically significant association between the growth rates of population and of per capita output (1995: p. 543).

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[1] We define East Asia to include China, Hong Kong, Japan, the Republic of Korea, Singapore, and Taiwan; Southeast Asia to include Cambodia, Indonesia, Laos, Malaysia, Myanmar (Burma), the Philippines, Thailand, and Vietnam; and South Asia to include Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka.

This "population neutralist" finding is surprising, but whether it arose because population has (a) no positive or negative effects on economic growth, (b) no net effect on economic growth, or (c) because both the pessimists and the optimists have mis-specified the test remains unclear.

More recent work has decomposed population growth into its fertility and mortality components and examined their independent effects on economic growth (Barlow 1994; Bloom and Freeman 1988; Brander and Dowrick 1994; Coale 1986; Kelley and Schmidt 1995). These studies find that measures of fertility, specifically past birth rates, are negatively and significantly associated with economic growth, whereas the effect of mortality is insignificant. This more recent work is the direct precursor of this paper, insofar as it justifies the decomposition on the grounds that changes in fertility and mortality imply very different changes in the age distribution. Population growth attributable to longevity improvements among the elderly should have an immediate negative effect on economic growth, as this implies a greater number of elderly to support. Population growth attributable to a general mortality decline has no effect, because the ratio of the economically active population to dependents stays the same. Population growth attributable to a rise in fertility should have an immediate negative effect on economic growth, given the presence of more mouths to feed, and so should population growth stemming from a fall in infant mortality. These latter demographic effects will, however, have a delayed positive impact on economic growth, because the economically active population will boom two decades later, potentially long after the aggregate population growth effect has disappeared. The question is, how great will the impact be?

This paper contributes to the population debate in four ways. First, like Kelley and Schmidt (1995), it uses the new empirical models of economic growth to isolate the effects of demography. It does this by incorporating demographic variables into a growth model similar to the one used in Asian Development Bank (1997) and Barro and Sala-i-Martin (1995). Second, the paper explores the possibility of reverse causality between economic growth and demographic change by using a two-stage specification in which instruments for the growth rate of the population are used to correct for possible endogeneity. Third, it introduces demography into the growth equations in a theoretically more appealing way than simply by the ad hoc addition of birth and death rates, specifically, by adding the growth rates of the total population and the economically active population. By doing so, population growth can affect economic growth by its overall rate of increase *and* by its age structure. The distinction matters. Finally, the paper highlights how changes in the growth of labor force per capita, changes in the savings rate, and changes in the investment rate are three plausible channels through which a changing age structure might affect the rate of economic growth (Bloom and Williamson 1997; Higgins and Williamson 1997).

The paper uses the econometric results to assess the extent to which population dynamics can help account for a significant portion of East Asia's economic miracle. East Asia is an excellent context in which to examine this effect for a number of reasons. First, it has experienced a more rapid demographic transition than any other region at any time in history. Second, we argue that the initial fall in infant mortality, which set the demographic transition in motion, was likely to have been exogenous in late 20th century East Asia. Third, East Asia has also experienced higher sustained rates of economic growth over the past 30 years than any other region at any other time in history. Fourth, East Asia is often compared with Southeast and South Asia, whose demographic transitions either began later or proceeded more slowly, and whose recent economic progress has not rivaled that of East Asia. Finally, analysts have badly neglected the potential role of population change in economic performance in the region, a neglect illustrated best by the World Bank's oft-quoted *East Asian Miracle* (1993). In redressing this imbalance the paper compares Asia with the rest of the world and Asia's subregions with each other.

The first major finding is that *population dynamics matter in the determination of economic growth.* But the overall population growth rate is not the mechanism driving economic performance. Rather, age distribution is the mechanism by which demographic variables affect economic growth. These age distribution effects seem to be purely transitional -- although a full transition can take more than 50 years -- and operate only when the growth rates of the working-age and dependent populations differ.

The demographic transition is induced by an initial decline in infant and child mortality, which swells the youth dependency cohort until fertility rates begin to fall. It thereby helps trigger an economic transition in which growth performance passes through three phases: initially it is impeded when the youth dependency cohort swells; it is abetted in the next phase about two decades later when the swollen cohort reaches working age; and it is modestly impeded again some decades later when this swollen cohort becomes elderly.

The second major finding is that *population dynamics account for a substantial share of East Asia's economic miracle.* Population dynamics account for somewhere between 1.4 and 1.9 percentage points of East Asian GDP per capita growth per year from 1965 to 1990, or as much as one-third of observed economic growth during the period. The economic miracle can, of course, be defined differently. Assume that the steady-state growth rate in East Asia is about 2 percent per year, in which case the "miracle" is everything in excess of that, or about 4.1 percent (6.1% - 2% = 4.1%). Under this definition, population dynamics could account for almost half of the miracle. A third or a half is certainly not everything, but it indicates that population dynamics may well be the most important growth determinant. Within Asia, the evidence also suggests that demographic divergence contributed to economic divergence during the same period. If Southeast and South Asia can use their mid-phase demographic "gift" in the same way that East Asia did, demographic convergence within Asia will contribute to economic convergence in the coming decades.

The next section describes the demographic transition in more detail, focusing on the difference between the experiences of Western Europe and Asia to show that demographic effects have been much more pronounced in Asia. The paper then describes the model and the recent literature on economic growth upon which it is based. This is followed by a section that presents the econometric results, and another that uses the econometrics to identify just how much of the East Asian miracle can be accounted for on the basis of demographic dynamics. A penultimate section discusses labor supply and capital accumulation, the most likely channels through which population dynamics affect economic growth. The paper concludes with an agenda for future research.

The Demographic Transition

The Demography

The demographic transition describes the change from pre-industrial high fertility and mortality to post-industrial low fertility and mortality. Figure 1 offers a stylized view of the transition. Declines in mortality mark the beginning of almost all demographic transitions, and changes in the age structure are exacerbated because infants and children enjoy most of these early declines in mortality. True, the improved survivor rates for children induce parents to reduce their fertility. If parents adjusted completely and immediately, there would be no youth glut and no acceleration in population growth. But they do not: their adjustment is slow, and thus the youth glut is large and persistent. After a lag, however, fertility begins to decline, which marks the next stage of the transition. The population growth rate is implicit in the first panel of Figure 1 as the difference between fertility and mortality. The second panel makes the population dynamics explicit: the demographic transition must be accompanied by a cycle in population growth *and* the age structure. Figure 1 and the rest of this paper treat the demographic system as if it were closed, and thus ignore external migration. Were it quantitatively important and if it responded to cohort gluts and scarcities, external migration might very well mute the impact of demographic transitions. In the late 20th century, international migrations are simply not great enough to matter except, perhaps, for the United States and some oil-producing countries in the Middle East (Bloom and Noor 1997). They mattered a great deal, however, in the age of relatively unrestricted mass migration prior to World War I (Williamson 1997). In any case, Figure 2 offers an illustration of these cohort effects for East Asia: the closest steep ridge shows the movement of the relative size of the cohort through time, and the second ridge behind the first shows the echo effect.[2]

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[2] China has been excluded from Figure 2, as its population is large enough to overwhelm the data from the rest of Asia. Including it, however, merely serves to reinforce the observed pattern.

These components of the demographic transition might have separate influences on economic growth. The population growth rate could influence economic growth for the reasons asserted by both the population pessimists and the optimists. The demographic transition could also affect economic growth through the age distribution. Coale and Hoover (1958) made the dependency rate the centerpiece of their analysis of the impact of large youth cohorts on savings, investment, and educational capital deepening. As they were -- by virtue of the decade in which they conducted their analysis -- constrained to study only the first, "burden," phase of the Asian demographic transition, they could not devote attention to the "gift" phase from the mid-1960s to the present that drives this analysis. Of course, the age distribution effect will operate to first lower, then raise, then lower again the ratio of the economically active population to the total population, and thus will have a transitional impact on labor force per capita growth.

Note that the demographic "gift" in the middle phase of the transition may or may not be realized; it represents a growth potential whose realization depends upon other features of the social, economic, and political environment. An examination of past performance should reveal whether or not it *was* realized.

Like industrial revolutions, demographic transitions take many decades to complete, but in the case of postwar East Asia it has been much faster than it was in 19th century Europe. Over a century and a half, Europe slowly improved its understanding of and practices with respect to basic sanitation, management of solid waste, provision of clean drinking water, and the elements of sound nutrition. It invested in these measures to reduce mortality and chronic malnutrition, and eventually eliminated famines (Fogel 1994). It cleaned up what Victorian reformers called "killer cities" (Williamson 1990). These factors, together with the advent of antibiotics and vaccines and recognition of the importance of preventive medicine, led to a gradual decline in mortality in Europe. Infant and child mortality led the decline because the very young, like the elderly, are most vulnerable to infectious disease, and because children are far more numerous than the elderly at early development stages, the decline in infant and child mortality matters most. The fertility rate also declined slowly, and the European demographic transition stretched out for more than 100 years (Coale and Watkins 1986).

The health investments and medical technologies that had been developed and put into practice in Europe did not exist in Asia until relatively recently; there was a large gap between best health practice prevailing in industrialized Europe and local health practice prevailing in Asia. The scope for the transmission of health technologies was enormous in the 1940s, because it had been pent up by de-globalization, two world wars, the Great Depression, and wars of colonial liberation. When the postwar transfer of this pent-up health technology finally took place, it happened in a rush. The process was speeded up even further by investment in health-improving social overhead, which was heavily financed by world funding agencies that did not exist prior to the 1940s. In short, the possibilities for Asia to catch up with the West in terms of health and demography were enormous in the late 1940s, and they were driven by factors external to Asia itself. In the half century since then, Asia has exploited the catch-up potential with such enthusiasm that it has produced one of the fastest and most dramatic demographic transitions ever.[3]

Asia's demographic transition followed the stylized model by starting with a decline in mortality rates. By the late 1940s, the crude death rate had begun to decline very rapidly throughout much of Asia. The decline proceeded most rapidly in East Asia (Figure 3) and was accompanied by an increase in life expectancy from 61.2 to 74.6 years from 1960 to 1992. Similar declines occurred in Southeast and South Asia, where life expectancy improved from 51.6 to 67.2 years and from 46.9 to 60.6 years, respectively. In the 1950s and 1960s, most of the aggregate mortality decline was being driven by its decline in the youngest cohorts (Bloom and Williamson 1997).

There are a number of possible explanations for the rapid decline in child mortality in Asia in the middle of this century. One possibility has already been suggested, that is, in the 1940s Asia escaped from some four or five decades of relative isolation, ushering in an era of health technology transfer and diffusion

[3] The language we use in this section is purposely similar to that used in the debate about economic catch up and convergence (Abramovitz 1986; Barro 1991; Baumol 1986; Sachs and Warner 1995), because we think that exactly the same reasoning applies to the demographic transition in Asia.

of new public health programs and techniques. For example, the medical advances that were implemented in postwar Asia had been accumulating on the technological shelf for at least two decades: penicillin was discovered in 1927, sulfa drugs in 1932, and bacitracin in 1943; streptomycin was isolated in 1943 and its curative value against tuberculosis demonstrated; the efficacy of chloroquine in treating malaria was demonstrated in 1943; and 1945 saw the non-military use of penicillin and 1948 the introduction of tetracycline. With the advent of these and other drugs, diseases that had once killed hundreds of thousands, and even millions, became treatable, and at low cost. In addition, the pesticide DDT became available in 1943. To cite just one example, DDT spraying in the late 1940s reduced the incidence of malaria in Sri Lanka dramatically: the crude death rate declined from 21.5 to 12.6 between 1945 and 1950, with the most precipitous drops in the most malarial areas (Livi-Bacci 1992). Figure 4 illustrates the effect by plotting changes in mortality in the most and least malarial zones of Sri Lanka between 1930 and 1960. While the least malarial areas show a gradual decline during the period, the decline is dramatic and steep between 1943 and 1949 in the most malarial zone.

Another possibility is that increased agricultural productivity and trade in food both raised nutrition sufficiently to lower infant mortality dramatically in less than a decade, and did so everywhere in Asia. This may be true, but it seems unlikely given that the magnitude and timing of the mortality decline was so similar everywhere in Asia, regardless of level of development and productivity performance in agriculture.

Resolving the debate between the view that favors an *exogenous* supply-side-driven fall in infant mortality in the 1940s and 1950s and one that favors an *endogenous* demand-side-driven fall matters, because it will influence the extent to which the demographic transition in East Asia was mostly exogenous to the economic miracle itself. Future research must resolve this issue.

It must be stressed that whether and how *fertility* responds to economic events (and to rising child survivor rates) is irrelevant to the discussion of whether these demographic shocks were exogenous to the economic miracle. The fertility decline is, of course, largely endogenous, but that response simply serves to mute the impact on population growth of the exogenous decline in child mortality that sets the whole demographic transition in motion. While the timing of the mortality decline was remarkably similar across rich and poor Asia -- suggesting exogenous forces at work -- the lag between the drop in mortality and fertility, as well as the size of the ensuing fertility fall, varied -- suggesting endogenous forces at work (Bloom and Williamson 1997, Figure 5; Feeney and Mason 1997). Figure 5 plots the decline in the crude birth rate for East, Southeast, and South Asia. While the crude birth rate in East Asia falls much more rapidly than in Southeast or South Asia, the timing is not so different. In most countries, like Korea, Malaysia, and Singapore, fertility began to decline about 15 years after the drop in child mortality. In other countries, like Thailand, the delay was longer, closer to 25 years. What is remarkable about the onset of the Asian fertility decline is that it occurred in such a short period and that it was so dramatic everywhere, even where the pace of economic development was slow (Caldwell and Caldwell 1996).[4]

The pace and timing of the demographic transition has led to enormously divergent trends in population growth and age structure across Asia. Figure 6 plots the ratio of the working-age population to the nonworking-age population for the three subregions in Asia. With only two precocious exceptions, Japan and Sri Lanka, Asia's surge to peak youth dependency rates occurred in the 1960s and 1970s, reflected in Figure 6 by the low ratio of working-age population to non-working-age population.

As Figure 6 demonstrates, the ratio of working-age population to non-working-age population has been rising in Asia since 1970, but this increase was especially dramatic in East Asia between 1975 and

[4]There are, of course, a number of possible explanations for the decline in fertility. Contraceptive use rates vary across Asia (Bloom and Williamson 1997, Table 5); government intervention accounts for some of this variance, while family demand, responding in part to economic events, accounts for the remainder. The big debate is over which factor mattered most. Two well-known demographers argue that government intervention mattered a great deal and that the intervention was distinctly Asian (Caldwell and Caldwell 1996). Another even offered an estimate: examining the decline in the total fertility rate from 1965 to 1975 for 68 developing countries, Boulier (1986) concluded that 27 percent was due to economic change and 40 percent to government-supported family planning, with the remainder representing a continuation of long-term trends. By contrast, Gertler and Molyneaux 1994 and Pritchett 1994 both find that socioeconomic variables such as income and education play a much more significant role in fertility decline than family planning does. The general view, however, seems to be that family planning programs have helped to trigger the decline in Asian fertility, beginning with India in 1951. But, as Sanderson and Tan 1995 point out, diminishing marginal returns may imply a reduced benefit to incremental government investments in family planning in countries with well-established programs.

1990. According to the United Nations (1991) projections, the ratio of working-age population to non-working-age population will peak in East Asia in 2010, ending the second phase of its demographic transition. With the exception of Japan, the elderly dependency rate has been mostly irrelevant to Asia in this century, even to the more economically mature East Asia. It will, of course, become very relevant to these older tigers as they enter the next century. Indeed, Figure 6 projects a decline in the ratio of the working-age to the non-working-age population after 2010 (the third phase of the demographic transition). This reflects the increase in the elderly dependency rate as the bulge in the age distribution works its way through East Asia's population pyramid. However, the elderly dependency rate will not become a dominant demographic force anywhere else in Asia even as late as 2030.

The Economic Hypothesis

We seek to measure the effects of population growth and of changes in population age structure on economic performance. Population growth is expected to influence economic growth through the channels discussed in the standard debate between optimists and pessimists, such as economies of scale or reductions in the capital-labor ratio. This paper, however, argues that in the early stages of the demographic transition, rising youth dependency burdens and falling working-age adult shares diminish per capita income growth. As the transition proceeds, falling youth dependency burdens and rising working-age adult shares promote per capita income growth. The early burden of having few workers and savers becomes a potential gift: a disproportionately high share of working-age adults. Later, the economic gift dissipates, as the share of elderly rises.

If this framework is correct, then some of the slower growth prior to 1970 can be attributed to East Asia's very heavy youth dependency burden, which, by itself, was depressing growth rates. Without the youth dependency burden, so the argument goes, East Asia would have had higher growth rates prior to 1970. As East Asia graduated from demographic burden to gift, the youth dependency burden decreased and the proportion of working-age adults increased. The result was an acceleration of the growth rate due to demographic forces. This and other transitional forces -- productivity gains from "borrowing" foreign technologies, from shifting labor from sectors with low productivity (agriculture) to sectors with high productivity (industry and services), from exploiting the potential of globalization -- served to push the growth rate far above its pre-1970 level to the "miraculous" rates of the past quarter century. The demographic transition accounts for a decrease in the growth rate associated with high youth dependency burdens and a subsequent rise in the growth rate stemming from the emergence of the demographic gift in place of the burden. Some time in the near future, however, East Asia's demographic gift will dissipate (and consequently, economic growth will tend to slow down) as the share of elderly in the population increases. Once the demographic transition is complete and the population age structure stabilizes, population growth will affect economic growth only insofar as it operates through level effects. Hence, any economic effect due to the changing age distribution is only temporary.

Figure 7 offers a stylized version of the economic hypothesis where the sustainable growth rate is taken to be about 2 percent per year. Note, however, that the contribution of the demographic transition to the East Asian miracle will also depend on how the miracle is defined. If it is defined as a share of per capita GDP growth between 1960 and 2010 in Figure 7, then the demographic transition accounts for about one-third of the miracle; if it is defined as the surplus over the sustainable rate, then the transition accounts for almost half; and if it is defined as the increase in growth rates from 1945-1960 to 1960-2010, then the transition accounts for almost three-quarters. What follows is a test of the hypothesis and a defense of the magnitudes Figure 7 suggests.

The Theoretical Framework

The cross-country growth equations estimated in the next section are derived from a conventional Solow-Swan model of economic growth.[5] Competitive firms take wages and the interest rate as given and

[5] The Solow-Swan model is a special case of the Ramsey model with fixed savings rates. However,

produce the same good. The savings rate is fixed and exogenously determined. Workers are identical. If we assume that production per worker (y) takes the form $y = Ak^{\alpha}$, where A is an index of total factor productivity, α is the output elasticity of capital, and k represents capital stock per worker, then we can derive equation (1) for the growth rate of y. Equation (1) will be familiar to anyone who has read a current advanced macroeconomics textbook (e.g., Barro and Sala-i-Martin 1995). It is also consistent with the empirical growth literature, especially that which focuses on conditional convergence (Barro 1991; Barro and Lee 1994; Mankiw, Romer, and Weil 1992; Sachs and Warner 1995).[6] In the Solow-Swan model, the average growth rate (g_y) of output per worker between any time T_1 and T_2 is proportional to the natural logarithm of the ratio of income per worker in the steady state (y^*) and income per worker at time T_1 as follows:

$$g_y = \frac{1}{T_2 - T_1} \ln\left(\frac{y(T_2)}{y(T_1)}\right) = \alpha \ln\left(\frac{y^*}{y(T_1)}\right). \tag{1}$$

We make two additional modifications to this model. The first involves the formulation of steady-state output. As in Asian Development Bank (1997), we assume that y^* is formed as

$$y^* = X\beta \tag{2}$$

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the empirical estimation equation derived by the log-linear approximation around the steady state is identical in both models.

6 For an alternative framework within which to model the demographic transition, see Ehrlich and Lui, 1991. Using an overlapping generations model, they show that utility-maximizing individuals will choose to have fewer children in response to an exogenous decline in mortality rates. The resultant investment in the quality, instead of in the quantity, of children can push a country onto an endogenous growth path, leading to higher growth rates. Meltzer 1995 includes health along with education as a factor of production in a standard Ramsey growth model. When fertility rates are endogenous, an exogenous decline in mortality can be shown once again to set the economy on a path of sustained economic growth with a parallel decline in population growth.

where X is a matrix with k determinants of the steady state. We also follow Asian Development Bank (1997) in our selection of the variables to include in X. These variables are average years of secondary schooling in the initial period (in natural logs), life expectancy in the initial period, natural resource abundance, a measure of openness, an index of institution quality, average government savings, and geographic variables that indicate the ratio of coastline to land area, whether there is access to major ports, and whether the country is located in the tropics.

The second modification involves changing the model from output per worker (y) to output per capita ($\tilde{y}$). We note that

$$\tilde{y} = \frac{Y}{N} = \frac{Y}{L}\frac{L}{N} = y\frac{L}{N} \tag{3}$$

where N is the total population, L is the number of workers, and $\tilde{y}$ is output per capita. This expression can easily be converted to growth rates,

$$g_{\tilde{y}} = g_y + g_{workers} - g_{population}. \tag{4}$$

When equations (1) and (2) are substituted into (4) and a stochastic term is added, the estimation equation (5) emerges:

$$g_{\tilde{y}} = X\Pi_1 + y(T_1)\Pi_2 + g_{workers}\Pi_3 + g_{population}\Pi_4 + \varepsilon \tag{5}$$

The theoretical implication of this equation is that $\Pi_3 = -\Pi_4 = 1$, which implies that for a stable population, where the growth rate of the workforce equals the growth rate of the population, net demographic effects should vanish. If the population is unstable (during a dynamic transition), then demography might matter.

It is possible as well that both population growth and growth in the labor force might affect the steady-state rate of growth. The Solow-Swan model posits an exogenous rate of growth of workers *n*. This is presumed to have a negative effect on growth through reductions in the capital-labor ratio. However, once demographic factors are incorporated, it becomes apparent that an increase in n relative to population growth will also reduce the dependency ratio. According to Coale and Hoover's (1958) hypothesis, this leads to increases in the per capita rate of savings, which will offset, and possibly even reverse, the negative effect of labor growth on the capital-labor ratio. If the increase in savings is more than proportional to the growth in labor, then increases in n will lead to a rise in the steady-state rate of growth. Alternatively, if it is less than proportional, the capital-labor ratio will decline and a fall in the steady state will occur. These effects on growth rates are not separately identified and will be absorbed into the coefficient on $g_{workers}$, potentially causing it to deviate from 1 in magnitude. The coefficient on $g_{population}$ will also absorb any influences of population growth on the steady state rate of economic growth, such as many of those cited in the debate between population optimists and pessimists. To the extent these influences are important, the coefficient on $g_{population}$ may deviate from -1.

Econometric Results

The econometric analysis is based on 78 Asian and non-Asian countries covering the quarter century from 1965 to 1990. It includes every country for which all the data exist. Table 8 provides a complete data description with sources and a list of the countries is provided in the appendix.

We start by asking whether the level of population growth affects economic growth, because the population debate has always been couched – erroneously we believe - in those terms. The results appear in Table 1. Most of the recent research on economic convergence has focused on the sign of the coefficient on logged initial income. If the coefficient is negative, the model predicts conditional convergence, that is, after controlling for factors that determine the steady-state level of income, poor countries tend to grow faster and approach their steady-state level more quickly than rich countries. Consistent with recent research on economic convergence, we also find conditional convergence in our sample. Our focus, however, is on the rate of population growth. In the revised specification in Table 1 (column 1), there is no significant relationship between population growth (GPOP6590) and GDP per capita growth, thereby supporting the neutralist position. Note, however, how sensitive this result is to the specification. As soon as log life expectancy in 1960 and two variables controlling for economic geography are added, population is shown to have a positive and significant impact on GDP per capita growth (Table 1, column 2), thereby supporting the optimists' position.

Table 1 illustrates the kind of analyses economic demographers have undertaken to examine the connection between demography and economic growth. It seems plausible, however, that both the sources of population growth and the stage of the demographic transition do matter: a child mortality decline and a baby boom both raise the share of young dependents in the population; a mortality decline among the elderly increases the share of the retired dependent age cohort; immigration raises the working-age population (because it self-selects young adults); and improved mortality among the population at large has no impact on age structure at all. Because an economy's productive capacity is directly linked to the size of its working-age population relative to its total population, distinguishing between the two components when exploring the impact of demographic change on economic performance seems natural and worthwhile.

Table 2 conforms to these notions: the growth rate in the economically active population (GEAP6590) joins GPOP6590 in the regression. The growth rate of the working-age population measures the change in the size of the population aged 15 to 64 between 1965 and 1990.[7] Table 2 confirms that the growth of the working-age population has a powerful positive impact on GDP per capita growth, while growth of the total population has a powerful negative impact. Consider the results reported in the second column of Table 2. The coefficient on the growth rate of the working-age population is positive, statistically significant, and large in magnitude: a 1 percent increase in the growth rate of the working-age population is associated with a 1.46 percent increase in the growth rate of GDP per capita. The coefficient on the growth rate of the total population is negative, statistically significant, and almost as large: a 1 percent decrease in

[7]Although other variables also help, our analyses suggest that they do not dominate the demographic influences.

the growth rate of the overall population (effectively, the dependent population, since the empirical specification holds fixed the growth rate of the working-age population) is associated with about a 1 percent increase in the growth rate of GDP per capita.[8] The third and fourth columns of Table 2 show what happens when the impact of the growth rate of the working-age population and that of the entire population are constrained to be equal, but of opposite sign. In steady state, when the age distribution is stable, population growth will not matter in either of these two specifications. In transition, when the age distribution changes, population growth does matter. The coefficient here is large, positive, and significant. Thus, in our sample, where the growth rate of the economically active population exceeds that of the overall population, higher GDP per capita growth rates have appeared (*ceteris paribus*). The opposite is true if the growth rate of the total population exceeds that of the economically active population. If the dependent population is growing more rapidly than the workforce, the estimates provide evidence of slower growth.

Previous contributions to the population debate have typically failed to explore the possibility of reverse causality between population growth and economic growth, despite a literature that suggests that economic events can induce demographic responses. While Table 2 uses ordinary least squares (OLS), Table 3 reports the results when an instrumental variables (IV) estimator is used to account for possible reverse causality.[9] In column 2 of Table 3, the coefficients on the growth rates of the working-age and the total population are similar to the OLS estimates: a 1 percentage point increase in the growth rate of the working-age population is associated with an increase of 1.37 percentage points in GDP per capita growth, and a 1 percentage point decrease in the growth rate of the total population is associated with an increase of 0.92 percentage points of GDP per capita growth. The IV estimates in specification 2, with high standard errors,

[8] The coefficients of the other variables are similar to those found in Asian Development Bank (1997) and Sachs, Radelet, and Lee (1997). Throughout this paper, specification 2 refers to these models, while specification 1 refers to a revised version that removes initial life expectancy and two variables intended to capture the effect of geography on economic performance.

[9] As the instruments we chose are available only for a smaller sample of countries, the OLS estimates corresponding to this sample are also included in the table. The instruments and the countries excluded from the smaller sample can be found in the notes to Table 3.

lack the precision of the OLS estimates, but the remaining three IV specifications yield more precise estimates.

When the coefficients on GEAP and GPOP are constrained to be equal and opposite in sign, the estimated IV coefficients are almost twice as large as their OLS counterparts. All of the constrained estimates are statistically significant at all conventional levels. The similarity of the signs and significance of these estimated coefficients across the alternative specifications and estimation techniques speaks well for the robustness of the result.

Hausman specification tests (Hausman 1978) were performed to test for consistency of the OLS estimates. The test statistics, reported in each column of Table 3, suggest that in both the constrained and unconstrained versions of the model one cannot reject the null hypothesis that the IV and OLS estimates are statistically equivalent. Thus, the data do not provide evidence of an endogeneity problem.

Table 4 reports the results when interaction terms and regional controls are included. The table deals with two issues: first, whether the effect of demographic change on economic performance is conditioned by key policy variables such as "institutional quality" and "openness"; and second, whether Asian growth responds differently to the same demographic and economic conditions compared with other regions. In the first four columns, the unconstrained versions of the model are re-estimated by including interactions between GEAP and a measure of the quality of institutions (Knack and Keefer 1995) on the one hand, and GEAP and a measure of openness (Sachs and Warner 1995) on the other. The last two columns explore whether any regional effect remains. There is no evidence supporting the view that the policy environment influences the linkage between population dynamics and economic performance. Further work will be required to examine the conditions that promote enjoyment of the demographic gift. There is some weak evidence that Asia grew faster than the omitted region, Africa, even after controlling for all of these forces, but there is no strong evidence that suggests that Asia -- after controlling for all these forces -- grew any faster than North America or Europe.

We have established that growth of the dependent population slows down economic growth. However, does a growing young dependent population have the same impact as a growing elderly dependent population? In Table 5, therefore, we modify the estimation equation by inserting the growth rates of the population under 15 and over 65 in place of the growth rate of the population as a whole. The results serve to sharpen our understanding of how dependent populations contribute to the slowdown. Table 5 offers two specifications (only the coefficients on the demographic variables are reported). The coefficient on the population under the age of 15 is negative and significant in both specifications: thus, a 1 percentage point increase in the growth of the population under age 15 is associated with a decrease in GDP per capita growth of about 0.4 percentage points (column 2). In contrast, a small, statistically insignificant, but positive coefficient emerges for the elderly population. We conjecture that since the elderly continue to make important economic contributions by tending the young, by working part-time, and perhaps by still saving, they are a smaller net drag than are the very young, whose labor participation and savings rates are trivial in magnitude. Because the elderly are currently a small minority of the total dependent population in Asia (11 percent in 1990), the relationship between the dependent young and GDP per capita growth dominates, accounting for the negative effect that the dependent population as a whole exerts on the growth rate of GDP per capita.

The economic impact of the demographic transition can be summarized this way: economic growth will be less rapid when the growth rate of the working-age population falls short of that of the population as a whole (an event that characterized the first phase of East Asia's postwar demographic transition prior to 1970); economic growth will be more rapid when the growth rate of the working-age population exceeds that of the population as a whole (an event that characterized the second phase of East Asia's postwar demographic transition overlapping the economic miracle during the past quarter century); and economic growth will be somewhat less rapid when the growth rate of the working-age population once again falls short of that of the entire population (an aging phenomenon -- the graying of East Asia -- that will dominate this subregion during the next quarter century).

Explaining the East Asian Miracle

So far, these results seem to be consistent with the stylized characterization in Figure 7, but they involve only hypothesis testing and statistical significance. What about economic significance? Can these population dynamics explain a significant part of the East Asian miracle?

Between 1965 and 1990, the working-age population in East Asia grew 2.4 percent per year, dramatically faster than the 1.6 percent rate for the entire population, and the 0.25 percent rate for the dependent population (Table 6). The working-age population also grew faster than the entire population in Southeast Asia, but the differences were almost half of those in East Asia, while in South Asia they were only a quarter of the East Asian figure.

These demographic differences help explain at least some of the disparity in growth performance across the subregions of Asia between 1965 and 1990. Combining the coefficients from the estimated growth equations in Table 4 and the growth rates of the working-age and total population, Table 6 indicates that population dynamics can explain between 1.4 and 1.9 percentage points of GDP per capita growth in East Asia, or as much as one-third of the miracle (1.9/6.11 = 0.31). If instead the miracle is defined as the difference between current GDP per capita growth (a transitional rate where population dynamics matter) and the estimated steady state of 2 percent (when population is also in steady state and has no impact), then population dynamics can explain almost half of the miracle (1.9/[6.11-2] = 0.46). In Southeast Asia, where the fertility decline took place a little later and the infant mortality decline was a little less dramatic, population dynamics still account for 0.9 to 1.8 points of economic growth, or again, as much as half of its (less impressive) miracle (1.8/3.8 = 0.47). In South Asia the incipient demographic transition accounts for only 0.4 to 1.3 percentage points of economic growth, but still as much as three-quarters of a poor growth performance (1.3/1.7 = 0.76). The countries that benefited most from these demographic changes were Hong Kong, Malaysia, Republic of Korea, Singapore, Taiwan, and Thailand -- all of which are old or new fastgrowing tigers. The biggest demographic contribution seems to have been in Singapore, at 1.9 to 2.3 percentage points, but Thailand is close behind, at 1.5 to 2.3 percentage points. It is no coincidence that these tigers attracted most of Krugman's attention when he asserted that the East Asian miracle was driven mainly by high rates of capital accumulation and labor force growth (Krugman 1994).10

Compared with the rest of the world, East Asia was the largest beneficiary of the population dynamics associated with demographic change. Europe received only a small post-baby-boom boost of 0.3 to 0.5 percentage points. Even South America's demographic impact, 0.7 to 1.5 percentage points, was smaller than East Asia's, although the demographic contribution was almost identical to that of Asia as a whole.

The future will look quite different. Table 7 offers a forecast based on the coefficients of the estimated growth model and the United Nations (1991) demographic projections up to the year 2025. In East Asia, the GDP per capita growth attributable to demographic influences is projected to be *negative* between 1990 and 2025, declining from a positive gain of 1.4 to 1.9 percentage points between 1965 and 1990 to a *loss* of 0.1 to 0.4 percentage points up to 2025, a projected slowing of 1.5 to 2.3 percentage points caused solely by demographic forces. The demographically induced growth loss is projected to be even larger in some parts of East Asia. If nothing happens to offset them, demographic events will induce a 2.0 to 2.4 percentage point decline in Hong Kong's GDP per capita growth rate, a 2.5 to 3.0 percentage point decline in Singapore, a 1.9 to 2.2 percentage point decline in Korea, and a 0.9 to 1.1 percentage point decline in

10 Krugman relied on the findings of Young (1994a, 1994b) and Kim and Lau (1994). In a recent study, however, Hsieh (1998) uses a price-based approach to calculating total factor productivity growth (TFPG) and gets much higher estimates -- especially for Singapore -- than those resulting from the conventional, quantity-based approaches. He attributes the differences between "primal" (quantity-based) and "dual" (price-based) estimates of TFPG to errors in national accounts data on quantities of output and capital. Hsieh argues that factor price data are more reliable, as they can be observed in a marketplace.

Japan. In contrast, South Asia will potentially enjoy a 0.8 to 1.4 percentage point growth rate *gain* as it leaves the early "burden" stage of the demographic transition and enters the "gift" stage, with the largest potential gains being for Pakistan and Bangladesh. Southeast Asia should register a slightly smaller demographic gift of 0.6 to 1.1 percentage points, with considerable variance across countries, with the biggest potential gainer being the Philippines and the biggest potential losers being Malaysia and Thailand.

Demographic divergence contributed to Asian economic divergence during the past quarter century, with South Asia falling behind East Asia; however, the demographic indicators most important to economic performance will converge across Asia up to 2025. If our hypotheses survive further scrutiny, then the demographic convergence should contribute to economic convergence during the next 30 years in the region. The East Asian connection between the demographic transition and the economic miracle is now being replayed in South Asia, and even more so in Southeast Asia. While demographic divergence has contributed to economic divergence in Asia over the last three to four decades, demographic convergence will contribute to economic convergence over the next three to four decades. Figure 8 offers a stylized characterization of those events.

Possible Channels of Impact

The macro evidence supports the hypothesis that demographic events matter in accounting for the East Asian economic miracle. Theory seems to offer an explanation for the correlation, but the hypothesis will be further strengthened if we can show evidence that the channels of impact have been working the way theory predicts. What follows suggests that demographic factors were indeed driving the labor force, and that they were also driving a good portion of the high and rising savings and investment rates.

The Impact of Demography on Labor Force Growth

How much of the fast-growth transition in Asia can be explained by the impact of demography on labor inputs? Elsewhere we offered some answers that are only summarized here (Bloom and Williamson 1997, Table 6). Our interest, of course, is in labor inputs *per person*. Labor input per person (working hours per capita, or H/P) growth can be separated into three parts: changing hours worked per worker (H/L); changing labor participation rates among those of working age (L/EAP); and changing shares of the population of working age (EAP/P), the pure demographic effect. Thus per capita hours worked can be decomposed into H/P = (H/L)(L/EAP)(EAP/P).

How much of Asian economic growth can be explained by a rise in labor input per capita brought about by purely demographic forces? Between 1965 and 1975, the answer is very little, but between 1975 and 1990, it is quite a lot. The rising working-age share served to augment the growth of labor input per capita by about 0.75 percentage points per year. This implies that about 0.4 percentage points of Asia's transitional growth since 1975 can be explained (or about a tenth of GDP per capita growth).[11] The figures are much larger for East Asia: growth in labor input per capita brought about by pure demography was more than 1.1 percentage points per year, equivalent to 0.6 percentage points of economic growth explained. As the previous section estimated that demographic forces could account for 1.4 to 1.9 percentage points of the East Asian miracle, their impact on labor input per capita appears to account for about 30 to 40 percent of the total demographic effect. The figures for Southeast Asia are more modest, a little more than 0.6 percentage points per year and thus a little less than 0.4 percentage points of economic growth explained. They are much smaller for South Asia. By itself, the pure demographic effect implies a 0.5 percentage point reduction in GDP per capita growth in South Asia compared with East Asia, thus contributing to economic divergence between the two regions since the early 1970s.[12]

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11 Calculated by multiplying the growth of labor input per capita by the output elasticity of labor. The output elasticity is taken to be 0.56, the average for the 1960s and 1970s of Japan, Hong Kong, India, Republic of Korea, Singapore, and Taiwan (Chenery, Robinson, and Syrquin 1986, Table 2-2).

12 How much of faster growth in East Asia, compared with the OECD, has been due simply to these demographic labor-input-per-capita forces? The answer is almost 0.5 percentage points, or about four-

These demographic labor-input-per-capita forces do not, of course, exhaust all influences on labor supply, nor do they exhaust all demographic transitional influences on the growth rate, but are they likely to persist in the future? It depends on where in Asia we look. The fall in the pure demographic effect will be a huge 1.13 percentage points per year in East Asia, causing growth to slow there by about 0.6 percentage points. In sharp contrast, the fall will raise South Asia's GDP per capita growth rate, although not by much. The demographic influence on labor inputs will, by itself, foster GDP per capita convergence between the poor South and the rich East, favoring growth in the South by 0.7 percentage points. Whether South Asia will actually realize this potential is, of course, a matter for conjecture.

Will these purely demographic contributions to the slowing of economic growth be offset by Asians working harder, and by their more active participation in the labor force? A more likely outcome is that Asians will work less hard as their incomes rise, just as workers before them have done in the more industrially mature countries. And fewer prime-age Asians will work, because they will be able to afford earlier retirement and will invest more in schooling. In any case, even if Asians work just as hard in the future, that part of the labor-input-per-capita growth effect will reduce to zero; they would have to work harder and harder simply to maintain the effect.

The Impact of Demography on Savings

Almost forty years ago Coale and Hoover (1958) proposed their famous dependency hypothesis. It was based on a simple, but powerful, intuition: rapid population growth from falling infant and child mortality and high or rising fertility swells the ranks of dependent young, thereby increasing consumption requirements at the expense of savings. Eventually, the youth dependency burden evolves into a young adult glut and the resulting savings boom contributes to an economic miracle. Finally, the demographic transition is manifested by a large elderly burden, low savings, and a deflation of the miracle. The Coale-Hoover hypothesis suggests that some of the impressive rise in Asian savings rates can be explained by the equally

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tenths of the gap between the two.

impressive decline in dependency burdens, that some of the difference in savings rates between sluggish South Asia and booming East Asia can be explained by their different dependency burdens, and that some of the savings rate gaps between the two regions should diminish as the youth dependency rate falls in South Asia and the elderly dependency rate rises in East Asia over the next three decades.

When examined in the light of time-series evidence, the Coale and Hoover (1958) hypothesis has seemed variously more and less valid. Leff's (1969) study appeared to place the youth dependency hypothesis on a solid empirical footing, but later research by Goldberger (1973), Ram (1982), and others failed to confirm the dependency hypothesis, and cast doubt on the validity of the empirical methods employed in the earlier studies. Theoretical developments also seemed to undermine the foundations of the dependency hypothesis. Tobin's (1967) life-cycle model held that the national savings rate should *increase* with faster population growth. The reason is simple, at least in that model: faster population growth tilts the age distribution toward young, saving households and away from older, dis-saving ones. The representative-agent elaboration of Robert Solow's neoclassical growth model pointed in the same direction as Tobin's, with faster population growth resulting in increased savings rates in response to heightened investment demand (Cass 1965; Phelps 1968; Solow 1956). However, the models just described failed to deal adequately with the dynamics implied by the demographic transition. The "age tilt" in Tobin's steady-state model occurs because the model describes a world restricted to active adults and retired dependents; it would imply a very different tilt if it also acknowledged youth dependency. Similarly, the neoclassical growth models assume fixed labor participation rates, and by implication assume no change in the dependency rate, which is exactly what one would assume in a model of steady-state behavior, but is inconsistent with the facts of demographic change. In effect, both models sacrifice the rich population dynamics implicit in Coale and Hoover's (1958) predictions about the Asian demographic *transition*.

In the 1980s Fry and Mason (1982) and Mason (1988) addressed the tension between the dependency rate and life-cycle models. These authors developed what they called a "variable rate-of-growth effect" model to link youth dependency and national savings rates. Their model rests on the premise that a decline in the youth dependency rate may induce changes in the *timing* of life-cycle consumption. If consumption is shifted from child-rearing to later, non-childrearing stages of the life-cycle, aggregate savings rise with a strength that depends directly on the growth rate of national income. As a result, the model suggests that the savings rate depends on the *product* of the youth-dependency ratio and the growth rate of national income (the "growth-tilt effect"), as well as on the dependency ratio itself (the "level effect").

Under the aegis of this new model, the dependency hypothesis has enjoyed something of a renaissance. The Coale-Hoover theory has evolved into explicit economic models that, now revised, account very well for cross-country savings variations in macro time series. Almost all recent analyses of macro data confirm the Coale-Hoover effects (Collins 1991; Harrigan 1996; Higgins 1994, 1998a; Kang 1994; Kelley and Schmidt 1995, 1996; Lee, Mason, and Miller 1997; Masson 1990; Taylor 1995; Taylor and Williamson 1994; Webb and Zia 1990; Williamson 1993), even if they receive weak support at best in household cross-sections (Deaton and Paxson 1997), a difference that future research needs to reconcile.[13]

Higgins and Williamson (1996, 1997) have estimated the largest macro impacts, and what follows uses their results. They estimate the effect of changes in population age distribution on changes in, not levels of, the savings rate as it deviated around the 1950-1992 mean. Thus East Asia's savings rate was 8.4 percentage points above its 1950-92 average in 1990-92 because of its transition to a much lighter dependency burden. Similarly, East Asia's savings rate in 1970-1974 was 5.2 percentage points below its 1950-1992 average because of its heavy dependency burden at that time. The total demographic swing was an enormous 13.6 percentage points, which would appear to account for the *entire* rise in the savings rate in East Asia during these 20 years. The figures for Southeast Asia are similar, but not quite so dramatic.

[13] Higgins (1998b) also points out that the results from analysis of the micro data and the macro data might not agree, as the data are not consistent. Specifically, "household survey data typically do not correspond to the appropriate concept of personal saving as measured by the national income accounts." He notes, as well, that data on the components of national savings (personal, corporate, and government) are difficult to find.

Lee, Mason, and Miller (1998) point out that Deaton and Paxson's analysis is essentially a comparative steady state analysis rather than a dynamic analysis, as they assume that "the age profiles of saving and income are invariant to changes in the rate of population growth." As the effects of the demographic transition depend crucially on dynamic changes, Lee et. al. argue that the Deaton and

Southeast Asia's savings rate was 7.9 percentage points higher in 1990-1992 than its 1950-1992 average because of its lighter dependency burden late in the 20th century, and 3.6 percentage points lower in 1970-1974 due to the heavier burden at that time. The total demographic swing was 11.5 percentage points, a smaller figure than for East Asia, but still apparently accounting for the entire rise in the savings rate in Southeast Asia after 1970. The region with the slowest demographic transition has been South Asia, so its far more modest changes in the savings rate are predictable.

To the extent that domestic saving constrains accumulation, falling dependency rates have played an important role in East Asia's economic miracle since 1970. Indeed, assuming the increase in investment to have been equal to the increase in savings, and assuming a capital-output ratio of 4, it follows that demographic changes raised accumulation rates in East Asia by 3.4 (13.6/4) percentage points, thus augmenting GDP per capita growth by an estimated 1.5 percentage points. Given that demographic forces have already been estimated to have raised East Asian growth rates by as much as 1.9 percentage points, about three-quarters of this growth seems to be due to capital accumulation responses. The figure is too high, of course, because of the unsupported assumption that domestic savings fully constrained investment.

The Impact of Demography on Investment

To the extent that East Asia was able to exploit global capital markets during the past quarter century, domestic savings supply is far less relevant than investment demand in determining accumulation performance. As the children of the baby boom became young adults, did not the increase in new workers imply the need for investment in infrastructure to get them to work, to equip them while at work, and to house them as they moved away from their parents?

When Higgins and Williamson (1996, 1997) test this augmented Coale-Hoover hypothesis on Asia's past, changing age distributions seem to have had the predicted impact. For East Asia, demographic effects have served to raise investment shares by 8.8 percentage points since the late 1960s. Using the same

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Paxson analysis misses such effects.

assumptions made in the previous section on savings, this implies a 1 percentage point rise in the rate of GDP per capita growth. In short, demographic forces appear to have contributed 0.6 percentage points to the East Asian miracle via labor inputs per capita and 1 percentage point via capital accumulation per capita, roughly consistent with the total demographic impact estimated using macro growth equations, 1.6 versus 1.4 to 1.9 percentage points. Thus labor force growth responses might account for about one-third of the positive demographic contribution to the miracle (0.6/1.9), capital accumulation responses for about half (1/1.9), and other forces for the small remainder.

Directions of Future Research

The findings presented herein are revisionist, and thus the methods and data used are likely to come under close scrutiny. Future studies will no doubt refine and revise our arguments. Already we can suggest five ways to further this line of research.

First, other theoretical approaches might be explored. The standard Solow-Swan model has, after all, been criticized. New ways of thinking about growth could provide other models in which demographic dynamics and economic growth could be assessed jointly. Second, as further advances in the growth literature define the steady state more effectively, the robustness of our results can be tested and the analysis extended. Third, far more work needs to be done to establish the sources of the demographic transition in Asia after World War II: how much of the transition was due to exogenous factors and how much to endogenous? Fourth, economists and demographers may search for other dramatic episodes of growth or decline, such as the age of mass migration (Taylor and Williamson 1994; Williamson 1997), the AIDS epidemic (Bloom and Mahal 1997), or the Russian mortality crisis of the early 1990s (Bloom and Malaney 1998) to see if this model proves equally applicable. Fifth, other approaches to understanding simultaneity in the effect of economic growth on population need to be developed, perhaps by analyzing the effects on demographic variables of large and unanticipated variations in income per capita such as those caused by oil price shocks in the 1970s and 1980s.

In any case, while the results presented here certainly do not *prove* that population dynamics affect economic growth during transitions, they do appear sufficiently robust to justify additional research on the economic-demographic connection. That research, we suggest, should focus not just on aggregate population growth, but more importantly on population dynamics as they affect the age distribution.

Table 1: OLS Regression of Economic Growth on Population Growth, 1965-90.
Dependent variable: Growth rate of real GDP per capita, 1965-90, in PPP terms
Sample includes 78 countries.

Independent Variables	OLS Estimates	
	(1) Specification 1 Revised	(2) Specification 2 Emerging Asia
GPOP6590	.16 (.20)	.56 (.16)
GDP per Capita as ratio of US log GDP per capita, 1965 (logged)	-1.50 (.25)	-2.30 (.22)
Log Life Expectancy, 1960		5.81 (.98)
Log Years of Secondary Schooling 1965	.82 (.18)	.37 (.15)
Natural Resource Abundance	-4.68 (1.35)	-2.40 (1.17)
Openness	2.23 (.47)	1.88 (.36)
Quality of Institutions	.21 (.10)	.22 (.07)
Access to ports (landlocked)	-.68 (.39)	-.87 (.29)
Average Gov't Savings, 1970-90	.18 (.04)	.15 (.03)
Located in the Tropics		-1.09 (.33)
Ratio of Coastline Distance to Land Area		.29 (.12)
Constant	-2.11 (.92)	-27.38 (4.3)
Adjusted R^2	.69	.83

Standard errors are reported in parentheses below coefficient estimates.

Table 2: Effects of Population Growth on Economic Growth, 1965-90.
Dependent variable: Growth rate of real GDP per capita, 1965-90, in PPP terms
Sample: 78 countries

Independent Variables	OLS Estimates			
	(1) Specification 1	(2) Specification 2	(3) Specification 1 (constrained)	(4) Specification 2 (constrained)
GEAP6590	1.95 (.38)	1.46 (.34)		
GPOP6590	-1.87 (.43)	-1.03 (.40)		
GEAP6590- GPOP6590			1.97 (.38)	1.68 (.35)
GDP per Capita as ratio of US GDP per capita, 1965	-1.36 (.21)	-2.00 (.21)	-1.39 (.21)	-1.97 (.22)
Log Life Expectancy, 1960		3.96 (.97)		2.94 (.97)
Log Years of Secondary Schooling 1965	.50 (.16)	.22 (.14)	.50 (.16)	.28 (.14)
Natural Resource Abundance	-4.86 (1.2)	-2.35 (1.0)	-4.86 (1.1)	-2.57 (1.1)
Openness	2.06 (.40)	1.92 (.32)	2.00 (.38)	1.72 (.33)
Quality of Institutions	.23 (.08)	.20 (.07)	.22 (.08)	.15 (.07)
Access to ports (landlocked)	-.35 (.34)	-.64 (.27)	-.31 (.32)	-.40 (.27)
Average Gov't Savings, 1970-90	.14 (.03)	.12 (.03)	.14 (.03)	.13 (.03)
Located in the Tropics		-1.31 (.30)		-1.20 (.31)
Ratio of Coastline Distance to Land Area		.24 (.11)		.23 (.12)
Constant	-2.46 (.79)	-19.5 (4.3)	-2.28 (.69)	-14.3 (4.1)
Adjusted R^2	.76	.86	.78	.85

Standard errors are reported in parentheses below coefficient estimates.
Column 1: Test of gpop6590=-geap6590: $F(1,68)=.22$; $Prob>F=.64$
Column 2: Test of gpop6590=-geap6590: $F(1,64)=9.03$; $Prob>F=.003$

Table 3: Instrumental Variables Estimates of the Effects of Population Growth on Economic Growth.
Dependent variable: Growth rate of real GDP per capita, 1965-90, in PPP terms.
Sample size: 70 Countries

Independent Variables		(1) Specification 1	(2) Specification 2	(3) Specification 1 (constrained)	(4) Specification 2 (constrained)
GEAP6590	IV	3.83 (.82)	1.37 (1.71)		
	OLS	1.95 (.40)	1.41 (.37)		
GPOP6590	IV	-4.19 (.96)	-.92 (2.12)		
	OLS	-1.93 (.45)	-.97 (.43)		
GEAP6590-GPOP6590	IV			3.52 (.75)	3.43 (.98)
	OLS			1.95 (.40)	1.60 (.38)
Hausman Specification Test (Chi Square w/ df)		7.13 (10 df)	.00 (13 df)	6.16 (9 df)	4.14 (12 df)

Standard errors are reported in parentheses below coefficient estimates.

Instruments from first stage regression include average growth of population from 1950-60, percentage of the urbanized population in 1965, population policy variables including attitudes toward fertility and population growth and whether a government agency exists to create population policy , and dummy variables for countries where the major religion was Muslim or Judeo-Christian.
The following countries are not included in truncated sample due to missing data: Botswana, Zaire, Niger, Hong Kong, Taiwan, Singapore, Haiti, and Tanzania.

Table 4: Effects of Population Growth on Economic Growth with Alternative Specifications, 1965-90.
Dependent variable: Growth rate of real GDP per capita, 1965-90, in PPP terms
Sample: 78 countries

Independent Variables	OLS Estimates					
	(1) Specification 1	(2) Specification 2	(3) Specification 1	(4) Specification 2	(5) Specification 1	(6) Specification 2
GEAP6590	1.94 (.66)	1.36 (.55)	2.03 (.43)	1.43 (.39)	1.91 (.45)	1.24 (.40)
GPOP6590	-1.87 (.45)	-1.01 (.41)	-1.88 (.43)	-1.02 (.40)	-1.72 (.49)	-.78 (.45)
Interaction Between GEAP & Instit'l Quality	.002 (.07)	.01 (.06)				
Interaction Between GEAP & Openness			-.12 (.31)	-.05 (.25)		
Asia Dummy					.81 (.44)	.60 (.35)
North America Dummy					.36 (.67)	.67 (.55)
South America Dummy					.08 (.49)	.35 (.42)
Europe Dummy					1.00 (.60)	.53 (.50)
Constant	-2.43 (1.35)	-19.3 (4.3)	-2.62 (.89)	-19.6 (4.3)	-2.89 (1.20)	-20.19 (4.4)
Adjusted R^2	.77	.86	.77	.86	.79	.86

Standard errors are reported in parentheses below coefficient estimates.

Because of data limitations, our sample does not include any countries in Eastern Europe. Furthermore, countries from the Middle East are included in the Asian dummy. When controlling for the Middle East separately, the coefficients on geap6590 and gpop6590 do not change significantly.

Table 5: Effects of Population Growth on Economic Growth with Alternative Specifications, 1965-90.
Dependent variable: Growth rate of real GDP per capita, 1965-90, in PPP terms
Sample: 78 countries

Independent Variables	OLS Estimates	
	(1) Specification 1	(2) Specification 2
GEAP6590	.82 (.21)	.81 (.18)
Growth Rate of Population < 15, 1965-90	-.71 (.16)	-.37 (.16)
Growth Rate of Population 65+, 1965-90	.11 (.10)	.08 (.08)
Adjusted R^2	.78	.86

Standard errors are reported in parentheses below coefficient estimates. Note that only the coefficients on the demographic variables are reported in the table.

Table 6: Contribution of Demographic Change to Past Economic Growth.

Regions	Average Growth Rate of Real GDP per Capita, 1965-90	Average Growth Rate of Population, 1965-90	Average Growth Rate of Economically Active Population, 1965-90	Average Growth Rate of Dependent Population, 1965-90	Estimated Contribution, 1965-90 (Columns correspond to specifications in Table 4)			
					(1)	(2)	(3)	(4)
Asia	3.33	2.32	2.76	1.56	1.04	1.64	.86	.73
East Asia	6.11	1.58	2.39	.25	1.71	1.87	1.60	1.37
Southeast Asia	3.80	2.36	2.90	1.66	1.25	1.81	1.07	.91
South Asia	1.71	2.27	2.51	1.95	.66	1.34	.48	.41
Africa	.97	2.64	2.62	2.92	.14	1.10	-.07	-.06
Europe	2.83	.53	.73	.15	.43	.52	.39	.33
South America	.85	2.06	2.50	1.71	1.03	1.54	.87	.74
North America	1.61	1.72	2.13	1.11	.94	1.34	.81	.69
Oceania	1.97	1.57	1.89	1.00	.74	1.14	.62	.53

These averages are unweighted country averages. Estimated contribution is created by multiplying the coefficients on geap6590 and gpop6590 by the regional averages for each of the reported specifications.

Table 7: Contribution of Demographic Change to Future Economic Growth.

Regions	Projected Growth Rate of Population, 1990-25	Projected Growth Rate of Economically Active Population, 1990-25	Projected Growth Rate of Dependent Population, 1990-25	Estimated Contribution, 1990-25 (Columns correspond to specifications in Table 4)			
				(1)	(2)	(3)	(4)
Asia	1.36	1.61	.99	.61	.99	.50	.43
East Asia	.43	.20	.87	-.40	-.14	-.44	-.38
Southeast Asia	1.29	1.66	.63	.83	1.10	.73	.62
South Asia	1.65	2.11	.90	1.02	1.38	.90	.77
Africa	2.40	2.78	1.88	.98	1.63	.73	.68
Europe	.17	-.004	.48	-.32	-.16	-.34	-.29
South America	1.50	1.87	.94	.82	1.15	.71	.60
North America	1.28	1.33	1.21	.21	.645	.11	.10
Oceania	1.08	.93	1.37	-.22	.24	-.31	-.26

These averages are unweighted country averages. Estimated contribution is created by multiplying the coefficients on geap6590 and gpop6590 by the regional averages for each of the reported specifications.

Table 8: Variable Definitions and Selected Descriptive Statistics.

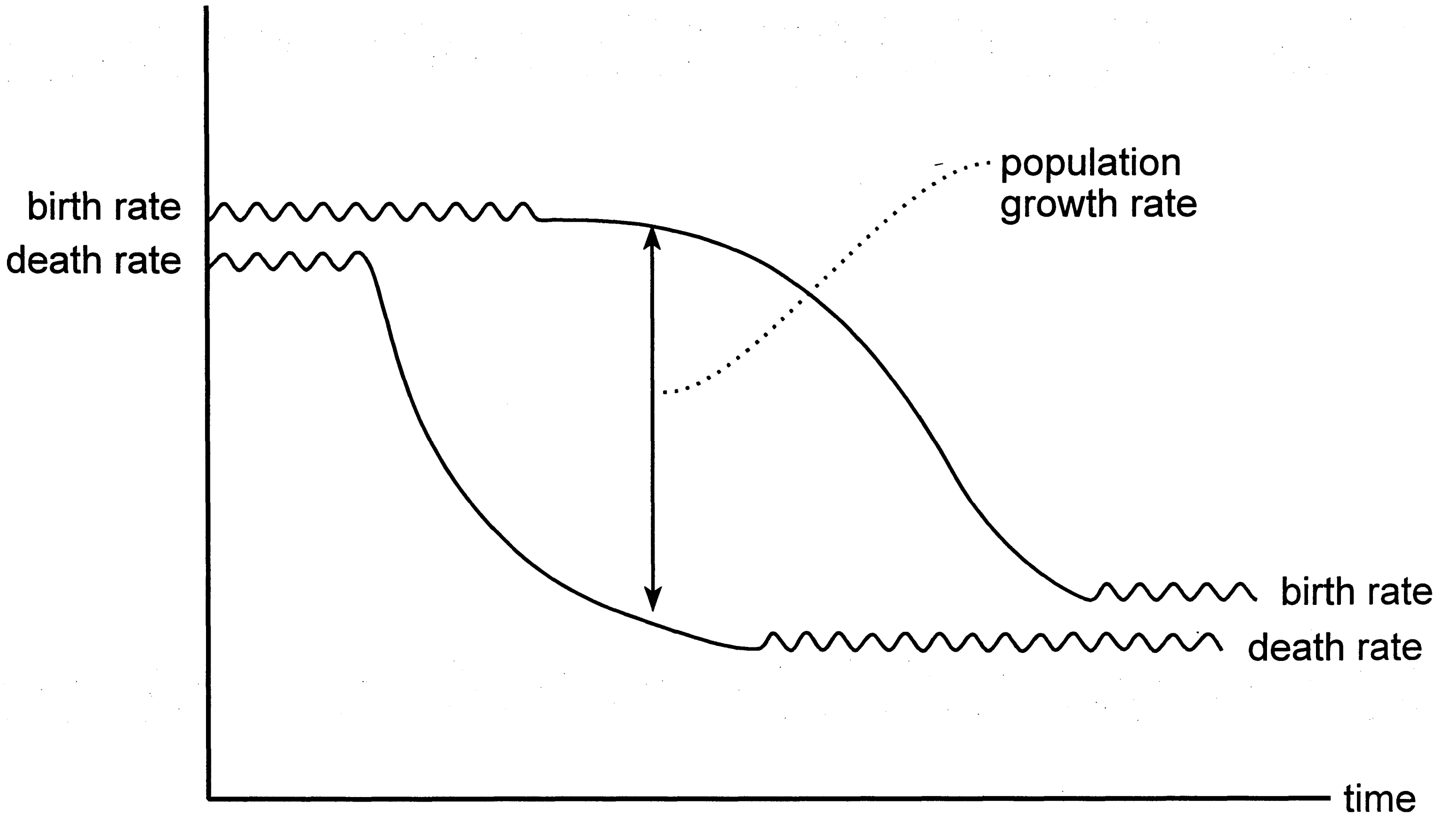
Variable Name	Definition (Source)	Mean	Standard Deviation	Min	Max
GPOP6590	Population Growth Rate, 1965-90. Source: World Bank.	1.88	1.00	0.17	3.49
GEAP6590	Growth rate of economically active population 1965-90. Source: World Bank.	2.17	1.03	0.25	3.63
Growth rate of population <15	Source: World Bank	1.11	1.53	-1.43	3.69
Growth rate of population 65+	Source: World Bank	2.62	0.98	0.79	5.73
Growth of the dependent population	Source: World Bank	1.46	1.17	-0.40	3.55
Average birth rate, 1967-87	Source: World Bank	30.89	12.56	13.7	53.9
Average death rate, 1967-87	Source: World Bank	11.68	5.04	5.15	28.85
Average infant death rate	Average infant death rate, 1967-87 Source: World Bank	2.54	2.52	0.12	9.70
Average non-infant death rate	Average non-infant death rate, 1967-87 Source: World Bank	9.03	3.21	3.87	19.55
GDP per Capita as ratio of US GDP per capita	Ratio of GDP per capita in country and US in 1965. Source: World Bank	-1.65	0.91	-3.34	-0.00
Schooling (log)	Average year of secondary school for population 15+ in 1965. Source: Barro&Lee	-0.70	1.15	-4.83	1.26
Life Expectancy (log)	Life expectancy in 1960. Source: World Bank	4.02	0.22	3.47	4.30
Natural Resource Abundance	Share of primary product exports in GDP in 1971. Source: World Bank	0.10	0.09	0.00	0.51
Access to ports	Dummy variable indicating if country is landlocked	0.13	.34	0.0	1.0
Openness	Source: Sachs & Warner	0.45	0.45	0.0	1.0
In the tropics	Dummy variable indicating if country is between the tropics	0.51	0.48	0.0	1.0
Ratio of coastline to land area	Source: World Bank	0.30	0.96	0.0	7.33
Growth of government savings, 1970-90	Expressed as share of GDP. Source: World Bank	1.44	3.43	-5.24	12.57
Growth of private savings, 1970-90	Expressed as share of GDP. Source: World Bank	15.94	9.57	-19.36	34.70
Quality of institutions	Source: Keefer and Knack index of the quality of governmental institutions.	6.11	2.42	2.27	9.98

Appendix
List of Countries Included in Data Set

1..	Botswana	40.	Uruguay
2.	Cameroon	41.	Venezuela
3.	Gambia	42.	Bangladesh
4.	Ghana	43.	China
5.	Guinea-Bissau	44.	Hong Kong
6.	Kenya	45.	India
7.	Malawi	46.	Indonesia
8.	Mali	47.	Israel
9.	Niger	48.	Japan
10.	Senegal	49.	Jordan
11.	Sierra Leone	50.	Korea
12.	South africa	51.	Malaysia
13.	Tanzania	52.	Pakistan
14.	Tunisia	53.	Philippines
15.	Uganda	54.	Singapore
16.	Zaire	55.	Sri Lanka
17.	Zambia	56.	Syria
18.	Zimbabwe	57.	Taiwan
19.	Canada	58.	Thailand
20.	Costa Rica	59.	Austria
21.	Dominican Rep.	60.	Belgium
22.	El Salvador	61.	Denmark
23.	Guatemala	62.	Finland
24.	Haiti	63.	France
25.	Honduras	64.	Germany, West
26.	Jamaica	65.	Greece
27.	Mexico	66.	Ireland
28.	Nicaragua	67.	Italy
29.	Trinidad & Tobago	68.	Netherlands
30.	United States	69.	Norway
31.	Argentina	70.	Portugal
32.	Bolivia	71.	Spain
33.	Brazil	72.	Sweden
34.	Chile	73.	Switzerland
35.	Colombia	74.	Turkey
36.	Ecuador	75.	United Kingdom
37.	Guyana	76.	Australia
38.	Paraguay	77.	New Zealand
39.	Peru	78.	Papua New Guinea

Figure 1

Demographic Transition



Population Growth and the Age Structure

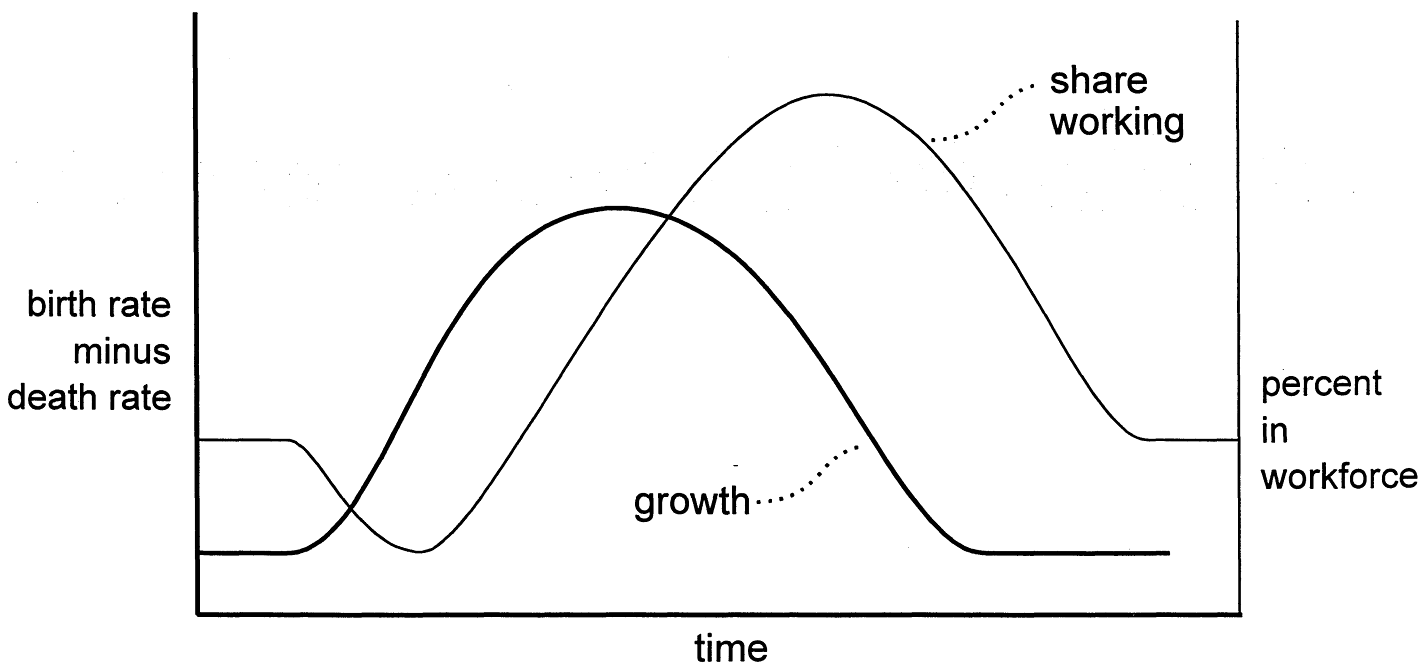
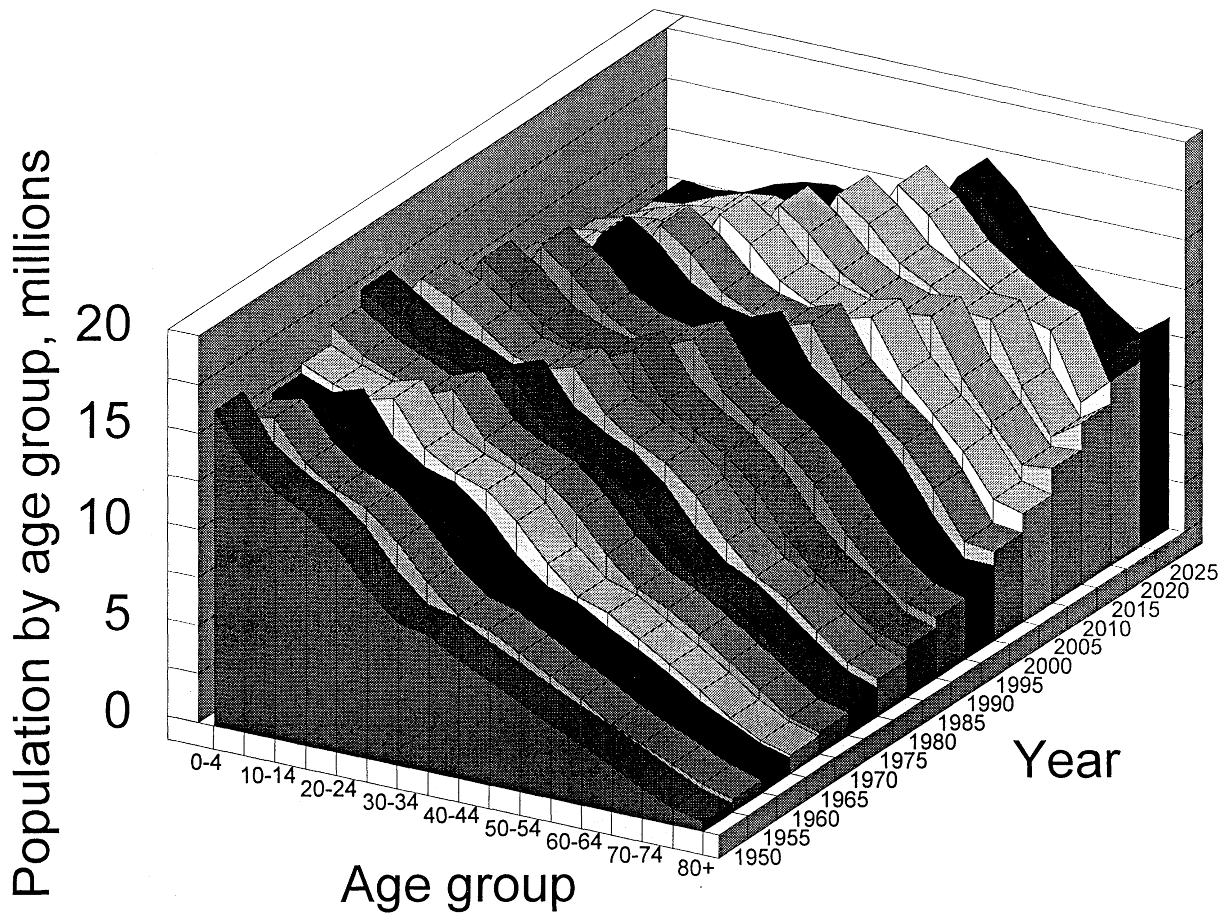


Figure 2. Changing Age Distribution

East Asia without China



Source: The Sex and Age Distributions of Population. The 1992 Revision of the United Nations' Global Population Estimates and Projections

Figure 3:Crude Death Rate by Subregion

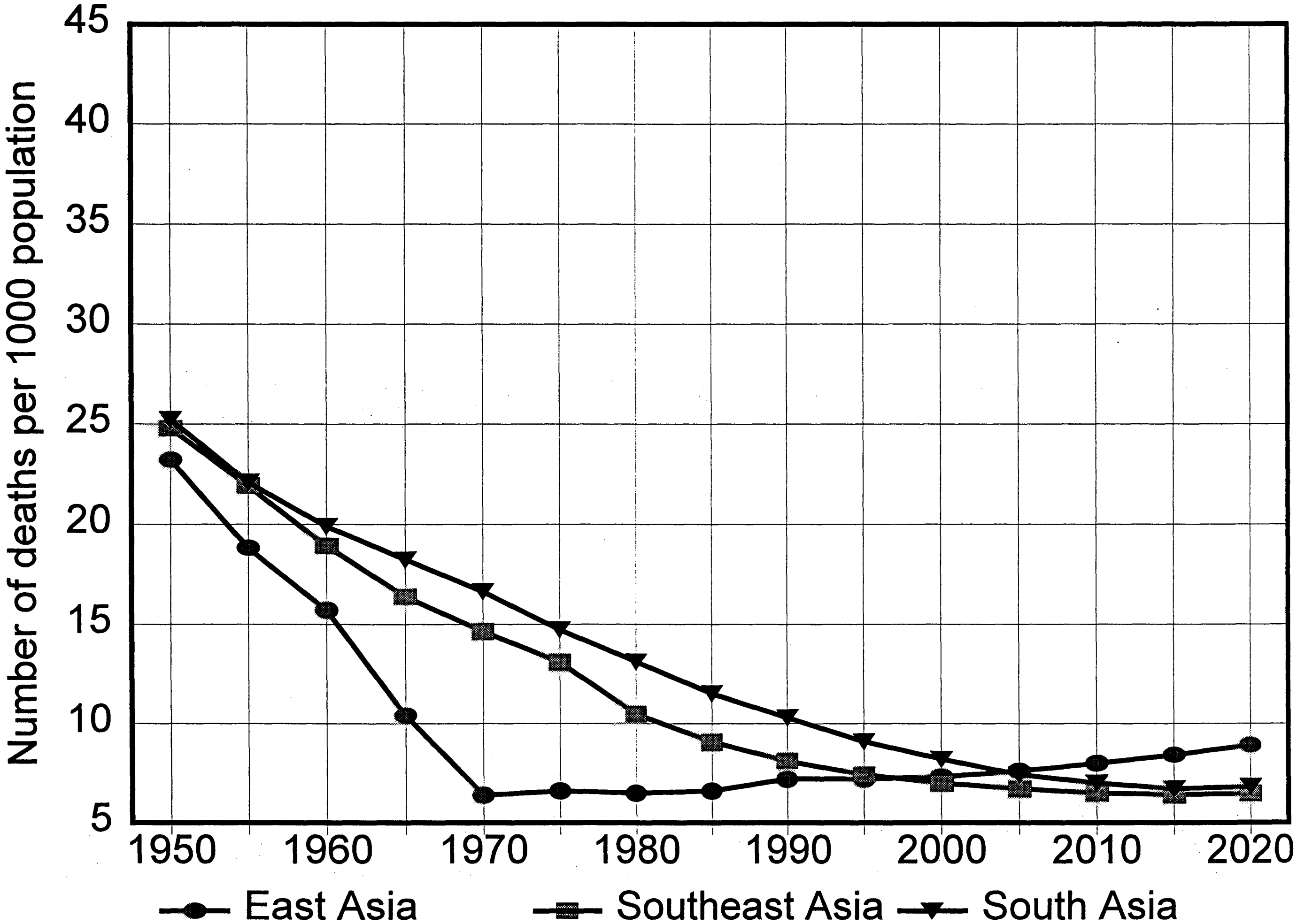
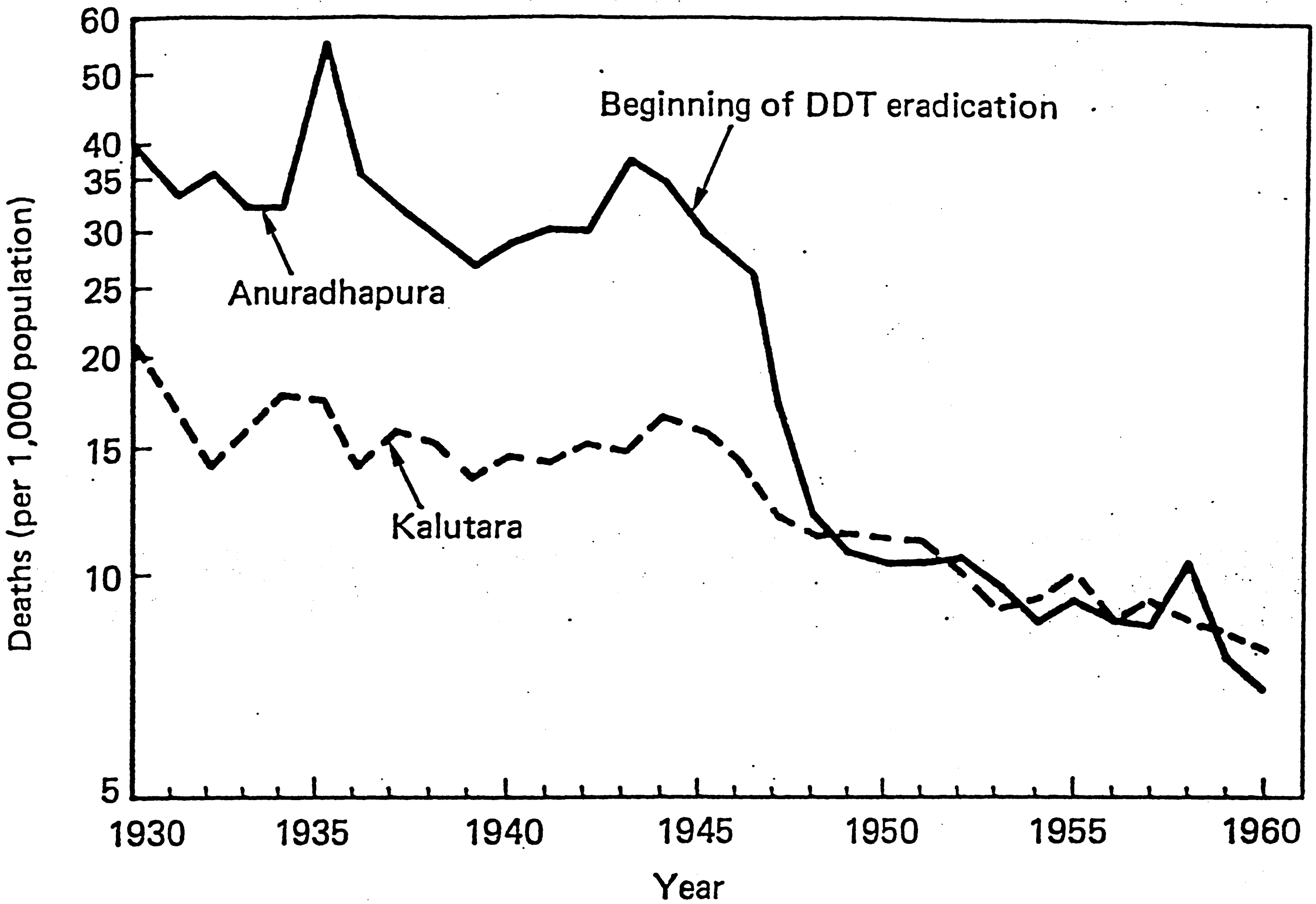


Figure 4

The Effect of DDT Usage on Mortality in Sri Lanka



Source: Livi-Bacci, Massimo (1992). *A Concise History of World Population.* Cambridge, MA: Blackwell, p. 157.

Figure 5:Crude Birth Rate by Subregion

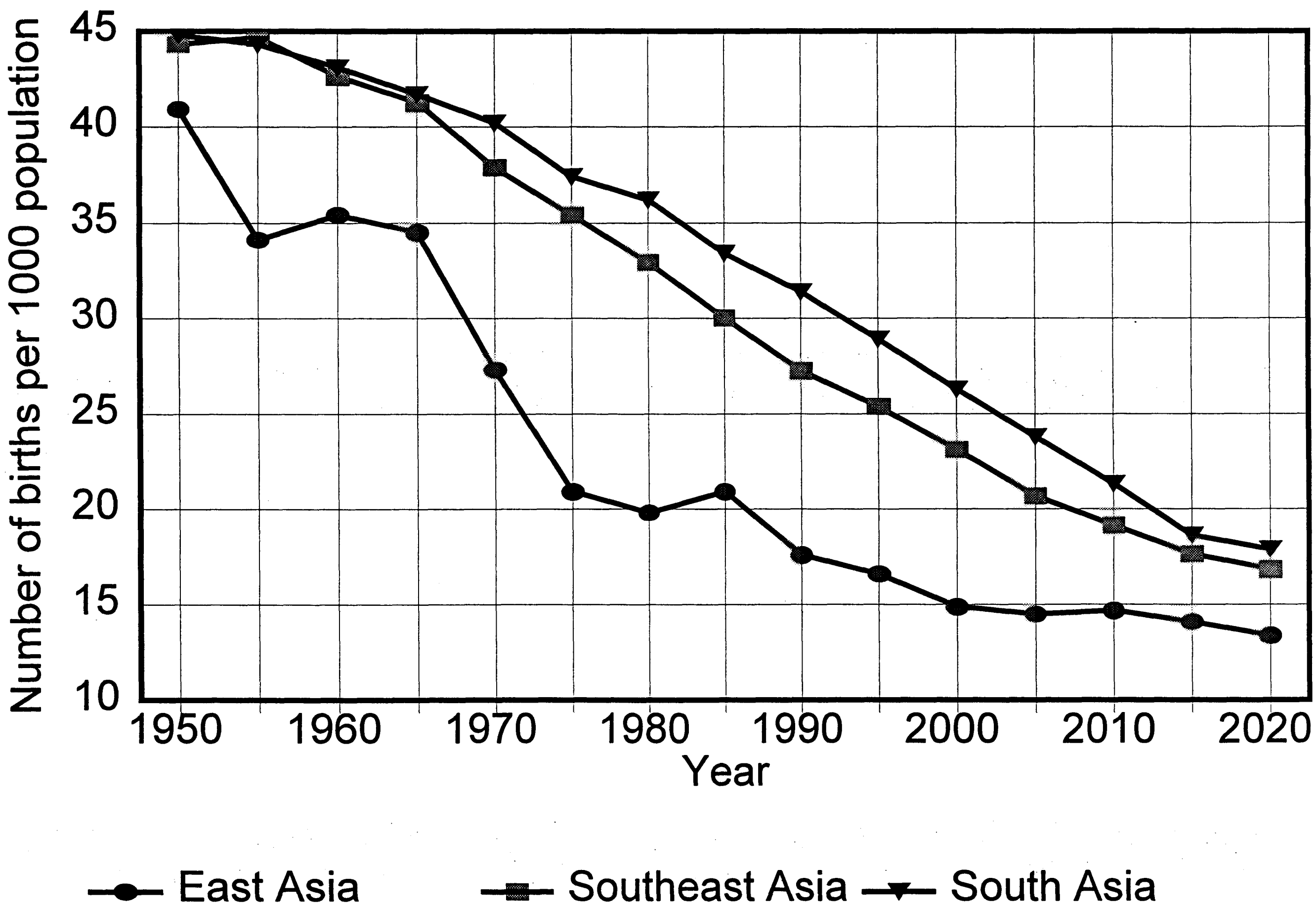


Figure 6: Ratio of Working-age to Non-working-age Population

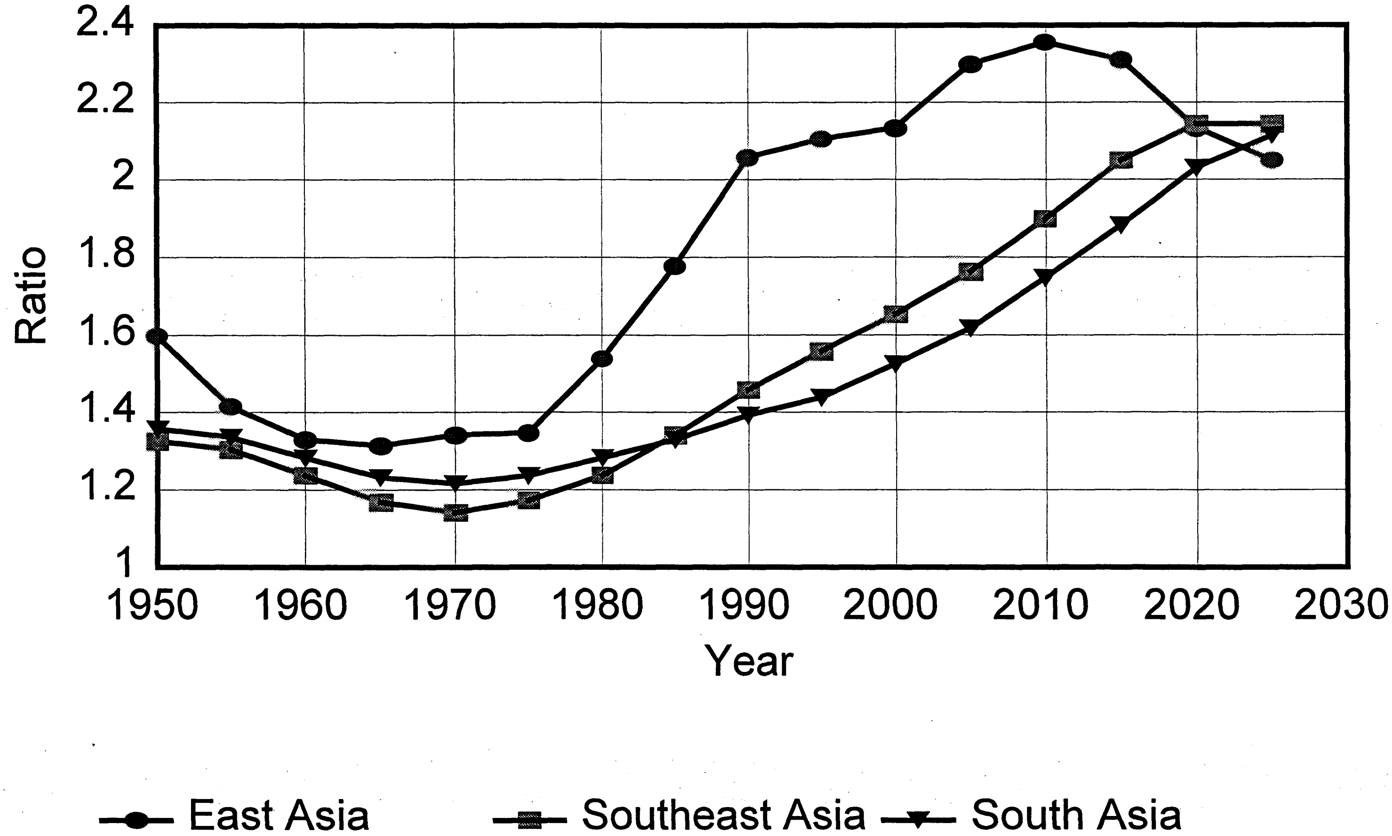


Figure 7

Stylized Model of Economic Growth
and the Demographic Transition in East Asia

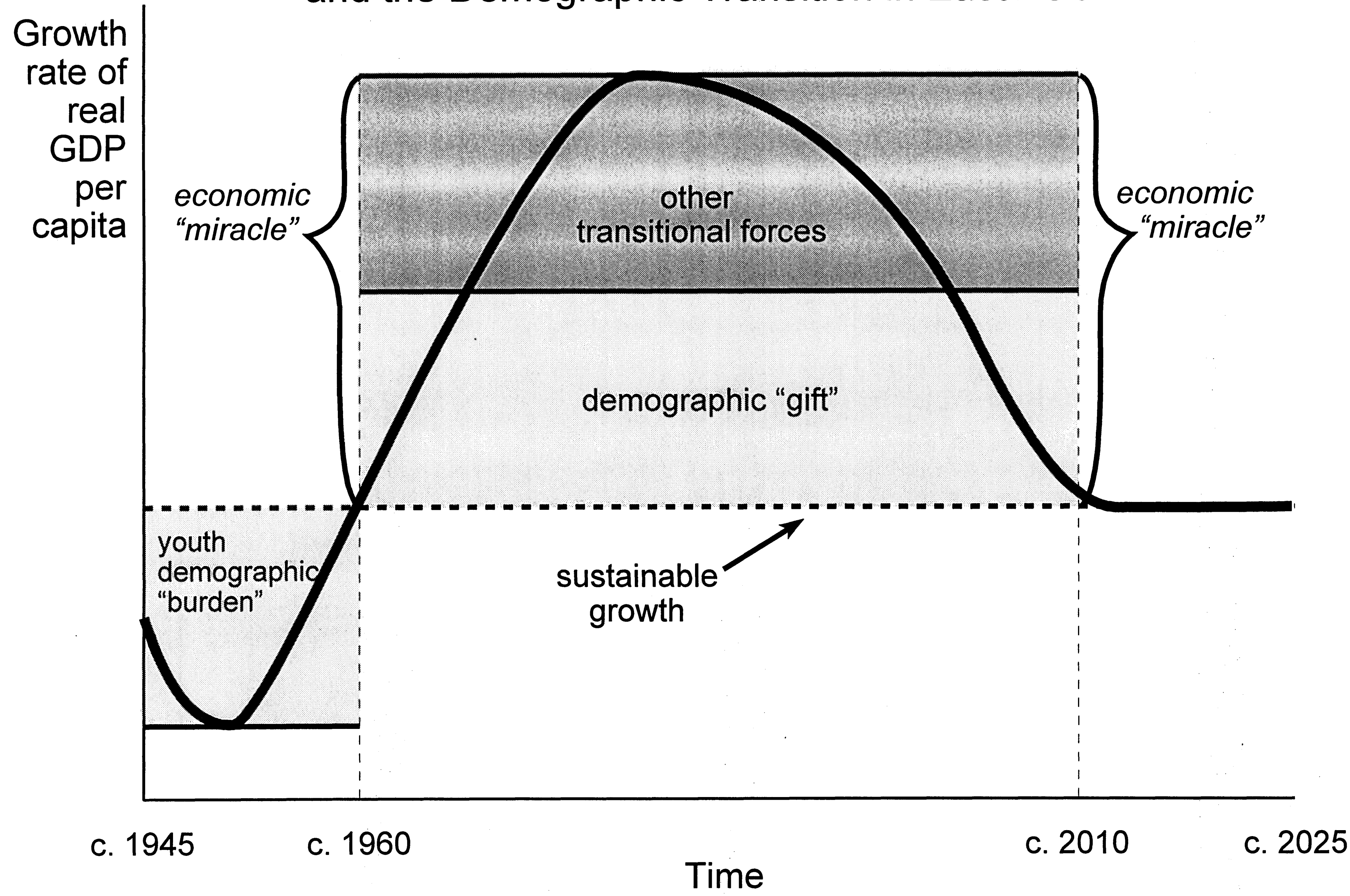
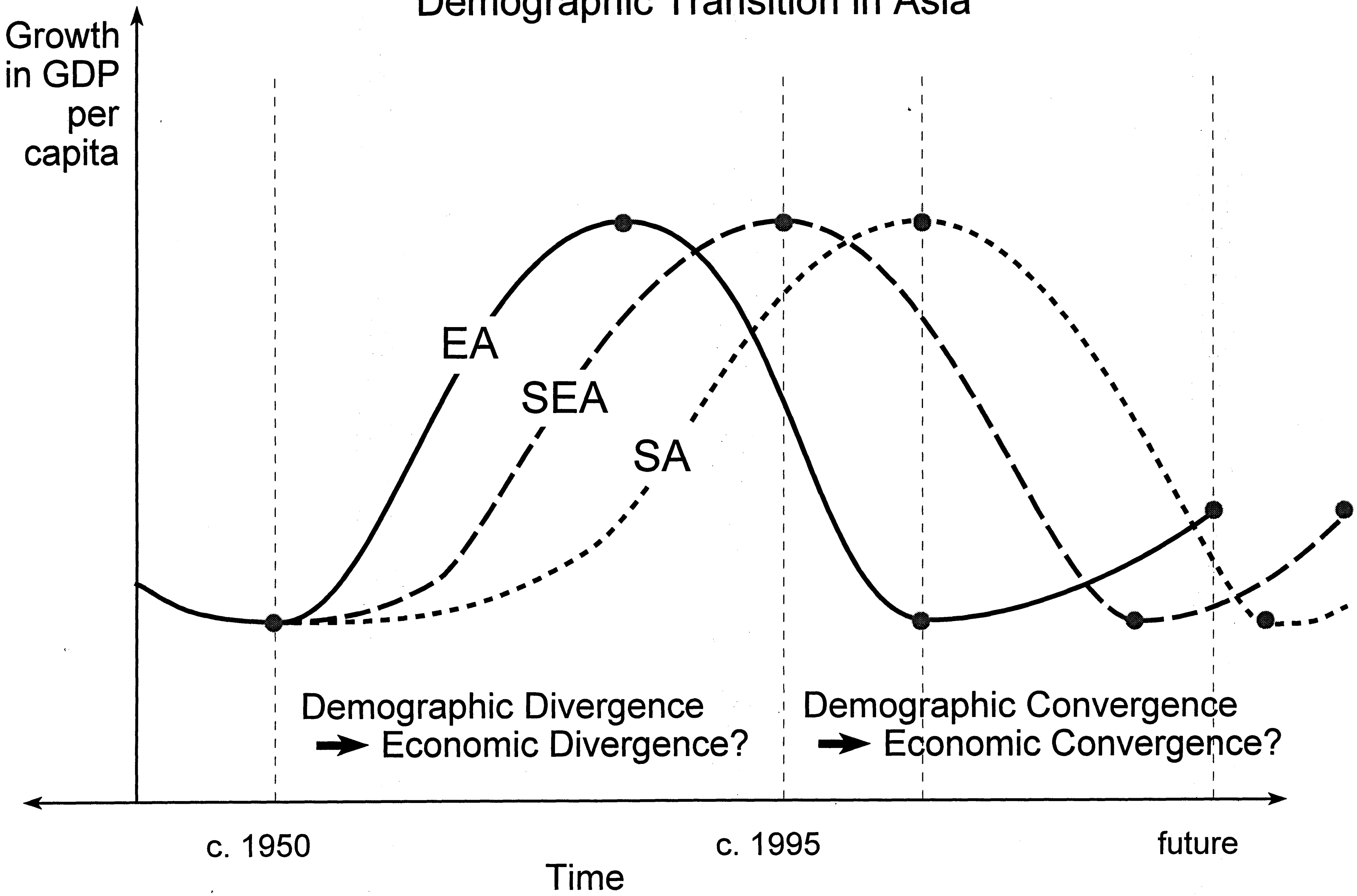


Figure 8

Stylized Model of Economic Growth and the Demographic Transition in Asia



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